PRE-CERAMIC POLYMERS IN FABRICATION OF CERAMIC COMPOSITES

BACKGROUND OF THE INVENTION

1. Field of the Invention

The invention is disclosed to a new class of composites comprising a ceramic powder which is formed into a threedimensional network or skeleton through the use of a ceramic-forming inorganic or organic precursor which 10 forms "necks" or bonds between the individual particles of the ceramic powder, and which, upon firing at elevated temperatures, forms a true ceramic bond between the particles. The powders may be coated on a substrate prior to firing, or may be compacted, molded, or used in conjunction with metallic preforms. After firing, the coatings, moldings, compacts and metallic-ceramic composites may be used as such or may be further impregnated with another material, e.g., a monomer which is polymerized in situ to form a new class of composite materials.

2. Description of the Related Art

It is known to cause sintering of ceramic powder particles under conditions of elevated temperature. For example, a metal oxide powder, such as alumina, will sinter by placing the ceramic powder in an environment having a temperature 25 in excess of 1100° C. It is also known to use a binder, such as an organic resin to give the ceramic powder "green strength". However, upon firing, the binder generally turns into a vapor and is not present in the sintered ceramic.

Thus, there remains in the art the requirements of high 30 temperature, requiring large amounts of energy to form sintered articles, which sometimes requires the use of temporary binders which serve no useful function after sintering, resulting in an extra cost in the manufacturing process which yields no beneficial effect in the sintered product.

OBJECTS OF THE INVENTION

It is an object of the invention to provide improved 40 properties in composite materials comprising ceramic powders.

It is a further object of the invention to provide simplified. low cost, low temperature methods of fabrication of ceramic

It is a still further object of the invention to provide a new class of composite materials based on incorporating organic infiltrants into at least a partially sintered ceramic skeleton

Another object of the invention is to provide new materials suitable for use as prostheses or cosmetic products, especially for dental and hard tissue replacement in animals and humans, especially dental restorations, cranial and bone plates, bone implants, replacement fingernails, composite implants such as metal-ceramic pins, screws, and other fasteners, structural products of improved toughness, low cost, low temperature coatings for enamelware, and other products based on ceramic powders.

artisan from the following description of the invention.

SUMMARY OF THE INVENTION

The first step in forming the new materials of the invention lies in creating a porous ceramic body, the ceramic 65 framework of the interpenetrating phase composite (hereinafter "IPC") having an inorganic phase, e.g., ceramic

as one component, by introducing and pyrolyzing a preceramic inorganic or organic precursor material.

During initial sintering "necks" of the ceramic precursor material form between individual particles of the ceramic powder, usually as the result of surface coating, and with heating under appropriate conditions, bind the individual particles together via ceramic bonds formed as interparticle necks by decomposition of the organic precursor material thus forming a framework or skeleton of a porous partially sintered body of ceramic.

In order to reduce the sintering conditions, e.g., time and/or temperature, a ceramic forming pre-ceramic forming inorganic or organic material, e.g., a monomer, oligomer or polymer can be introduced into the ceramic powder, usually in a solvent, to assist in the forming of the necks of material between the individual ceramic particles to form the ceramic particles into a porous framework.

Upon formation of the porous, three-dimensional framework or skeleton, the porous ceramic skeleton may be subsequently impregnated with a second polymeric material, which may be the same as the pre-ceramic polymer, or different, e.g., a poly(methyl methacrylate).

For example, polymerization of the organic material, e.g., methyl methacrylate, within the porous framework results in translucent blocks which are easily machined and have tensile strengths ranging from 50-200 MPa.

Alternatively, the pre-ceramic forming inorganic or organic material and ceramic powder can be coated onto a preform, such as a titanium pin or screw, or a substrate, such as enamelware, and heated to a suitable temperature to form a low cost, low temperature coating. In certain embodiments, the coating may be subsequently infiltrated by a toughening organic material, which may be the same as, or different from, the precursor forming inorganic or organic material, to introduce further specific properties, such as aesthetics, scratch-resistance, chipping resistance, hydrophobicity, dielectric properties or bioactivity.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a graphic representation of the mean fracture stress as a function of pyrolysis temperature for the weight percentage of each of the poly(dimethylsiloxane) solutions depicted therein;

FIG. 2 is a graphic representation of the response surface fit to mean fracture stress data.

DETAILED DESCRIPTION OF THE INVENTION

The first step in creating an interpenetrating phase composite (IPC) involves compacting a suitable ceramic powder. Theoretically any ceramic powder can be employed in the invention. By "ceramic" throughout the specification and claims, we mean metal oxides, such as alumina, as well as non-oxides of metal, e.g., silicon nitride and silicon carbide; in either the crystalline, or amorphous, state, e.g., glasses. Examples of suitable ceramics include alumina, zirconia, spinels, titanium dioxide, biologically active glass (such as These and other objects will be apparent to the skilled 60 these sold under the trademark BIOGLASS), feldspathic ceramics, such as, feldspathic dental ceramics, and calcium hydroxyapatites. Ceramics also include mixed powders including mixed glassy powders with metal oxides. Particle size is preferably in a range of particle size so as to achieve any desired packing density. While dense packing may be desirable in certain circumstances, in all cases the production of porous bodies is desirable, with the degree of